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Front cover: *Hakea yambulla*. Photo Sue Forrester. See p. 149.
Back cover: 'The Cottony-Cushion Scale (*Icerya purchasi*. -Maskell).' From French (1893) Part II, Plate XIX, p. 34. See p. 128.

Review and update of the nomenclature of the arthropods discussed by Charles French in his work *A Handbook of the Destructive Insects of Victoria*

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Abstract
The nomenclature of all arthropods treated in Charles French's monumental *A Handbook of the Destructive Insects of Victoria* is reviewed and, where necessary, updated to increase the current value of this work. A systematic checklist of all taxa includes all changes needed for recognition of the species discussed, and is preceded by a historical introduction to the importance and gestation of the Handbook. (*The Victorian Naturalist* 138(5), 2021, 128–144)

Keywords: applied entomology, entomological history, pest management

Introduction

Charles French Snr (1842–1933) was a leading figure in the development of entomology in Australia. In 1889, he was appointed Victoria's first Government Entomologist and, from 1911, was succeeded in that role by his son (Charles French Jr). His work laid the first solid foundations for the pursuit of insect pest management in Victoria, where his official duties were primarily to investigate and advise on the destructive insects influencing the agricultural industry. He is famed for his wide entomological and ornithological interests, both of which came to the fore in the five volumes of his *A Handbook of the Destructive Insects of Victoria* (1891–1911, hereafter the Handbook) published during his life time. These works have had lasting influence and continue to be of interest. Confirming the existence of an unpublished sixth volume of this work (noted by French in the Preface to Part V as ready and intended to complete the series) had long been a 'holy grail' of Australian entomology. Many people believed that it had been lost, so the notable rediscovery of the manuscript and its subsequent publication (French 2013) completed French's lifetime contribution and endorsed his hope that the completed Handbook would be a standard work for Australia on the subject of Economic Entomology and Ornithology. That his work was disseminated widely is reflected in the fact that Part I sold out its run of 8000 copies and was reprinted, with some minor changes to illustration attributions, in 1904. Earlier, French had noted that the print run of that first part was to be 9000 copies, and the reduced figure is quoted from the Preface to Part IV, in which he noted that the run was 'long since exhausted' (1909: 15) and that demand for the other volumes had been 'of a most satisfying nature' (1909: 15). Hogan (1994: 279) regarded the Handbook as 'monumental' and wrote that it included comments that reflect 'deep insight in relation to biological problems'.

The primary purpose of the Handbook reflected Charles French's official duties as Government Entomologist. French, and later his son (Charles French Jr, referred to frequently in the text in terms such as 'the Assistant Entomologist, Mr French jun'), acquired considerable knowledge of all insect groups containing species of economic importance. The scheme used in the Handbook was perhaps initiated in what seems to be his first compilatory publishing exercise—or, at least, that for which he is acknowledged, namely the series of card-printed illustrations of insects designed for a wall-hanging in school classrooms, and for which the cover details read 'McCarron, Bird & Co's descriptive chart of Destructive Insects published with the approval of the Education Department of Victoria and revised by C. French,

Esq., FLS, FRHS, Government Entomologist of Victoria'. Published in 1890, this chart teaching aid seems to have become very rare, but was in one sense a forerunner of the Handbook.

For each species treated in the Handbook, biological details are intermingled with economic concerns and methods of control or suppression; should additional significant information accrue, it was sometimes included in later Parts, so that the entire work had lasting contemporary value and relevance. Much of the information presented had not previously been assembled in this way, but French readily acknowledged help he received from other entomologists and naturalists, perhaps most notably from his counterpart in New South Wales, Walter Wilson Froggatt, with whom his interests and duties overlapped considerably. Froggatt was appointed as New South Wales Government Entomologist in 1896 and, whilst living in Bendigo, had initially contacted French in about 1883. Froggatt wrote prolifically. His long series of papers on individual insects and wider entomological topics, mostly published in the Agricultural Gazette of New South Wales or (for many of his more formal taxonomic studies) the Proceedings of the Linnean Society of New South Wales, were drawn largely from the same regional insect fauna as those treated by French, who clearly would have read these as they appeared (from 1890). Nowadays, Froggatt is perhaps best remembered as the author of the first major textbook about Australian insects, titled *Australian Insects* (Froggatt 1907), in which the acknowledgements include 'From Mr C. French and C. French Jr, I have had the loan of papers, books and specimens unobtainable in Sydney' (Froggatt 1907: xiv). Again in parallel with French, Froggatt was a founder, in 1891, of the Naturalists' Society of New South Wales, and was also a keen ornithologist. French did not hesitate to quote extensively and directly from the writings of Froggatt and other contemporary entomologists. Wherever pertinent information was available it was sought and assembled, with due attribution. The longest text chapter (21 pages in Part IV) on fruit flies, for example, contains extensive text from writings of both Froggatt and Tryon (see below). Around the same period, in Tasmania, the Rev EH Thompson produced books about insect pests (Thompson 1892, with eight uncoloured plates) and insect and fungus pests (Thompson 1895), emphasising orchard pests. From 1891 to 1896, Thompson was entomologist and scientific advisor to the Tasmanian Council of Agriculture, and from 1899 was eventually succeeded in that role by AM Lea. Like both French and Froggatt, Thompson was fundamentally an observant naturalist with strong entomological interests—a background that enabled all three to provide sound practical advice to pragmatic growers. Their interests were shared by their contemporary in Queensland, H Tryon, who was appointed Entomologist to the Department of Agriculture and Stock from 1893 to 1901, thereafter assuming a wider role that also encompassed plant diseases. In addition, he published series of accounts of individual insect species, but his major compilation, Report on Insects and Fungus Pests (Tryon 1889), pre-dated French's Handbook by two years.

The range of insect species included in the Handbook is dominated by Coleoptera (56 species), Lepidoptera (45 species) and Hemiptera (25 species), with smaller numbers of Diptera, Hymenoptera, Isoptera, Orthoptera, Thysanoptera and mites. Most are native species, with much of the information on their natural history not previously available, but introduced pests are also included. Each species' treatment is accompanied by a colour plate of the insect. Many of the plates also illustrate the early developmental stages, significant natural enemies, indications of habitat and symptomology and, where necessary, a text section on 'Prevention and Remedies'. The plates are an excellent recognition aid and were no doubt partially responsible for the Handbook's wide appeal. The first five parts, published up to 1911, included discussions of 132 arthropod species; Part VI (2013) added a further 22 taxa or pest groups. Each part included a miscellany of taxa, across various orders and in no fixed taxonomic sequence, so that the resulting sequence was a combination of opportunism and ecological theme, in some cases unified by a comment in the preface. The arrangement brought together insects attacking particular crops, thus facilitating use by growers, and constituting by far the most useful compendium then avail-

able to them. Thus, Part I is about apricots and cherries (Fig. 1), a theme continued in Part II, in which vegetable pests are also included. Part III is more of a miscellany. Forestry pests gain ascendancy in Part IV, and Part V is targeted as 'prominence given to insects attacking forests' (1911: 3). The anticipatory comment for Part VI implied that it would deal with beneficial insects. The collective Handbook, however, was of wider interest, each part containing chapters on general entomological themes, or reprinting the relevant government Acts. The inclusion of sections on 'useful' birds manifested French's wider recognition of pest insect management. These birds are listed in Part I; and 44 species are treated individually, with colour plates as well as text. Some of the content overlaps that of another book, *The Insectivorous Birds of Victoria*, by R Hall (1900). The short chapters on general entomology (attributed as being from EA Ormerod, a leading contemporary British applied entomologist), insect classification (taken from JO Westwood's classic arrangement), and collecting methods at the beginning of Part I almost pre-empt a more general entomology text! The relevance of the volumes to agriculture is augmented by the inclusion of the various Acts and Regulations governing quarantine and export/import requirements. Parts I–III each have substantial illustrated appendices of the spraying machinery available for use.

Not all insects included are proven pests, and a few were included because of their abundance or association with particular trees or crops. In Part IV, for example, referring to a hepialid moth '*Porina fusco-maculata* Walker' (Fig. 2), French wrote: 'I have included this moth in the destructive insects list, as the caterpillars, being large and living a long time in the ground, must do a lot of damage ...' (1909: 75). With numerous observations on insect behaviour and characteristics, the Handbook thereby assumed wider interests as a natural history book.

The modern era of narrow specialisation in science ensures that entomological polymaths of French's stature, endowed with the freedom to develop those interests broadly, are now rare. It also ensures that any modern attempt to construct an up-to-date version of his Handbook with such broad scope would necessarily be a team effort. Nevertheless, current appreciation of the diversity and impacts of insects on Victoria's industry and economy traces back to the five long-available parts of French's Handbook that became the standard reference for at least the first half of the twentieth century. It is perhaps no exaggeration to claim that all later agricultural and forestry pest management in Victoria has benefited from the Handbook, and that all later practitioners have drawn on its content. An important component of the 'French legacy' (from both father and son) has therefore been a strong foundation for understanding and advancing these disciplines, and the need for knowledge-based management ('control') of a wide variety of native and alien pest insects that collectively affect most agricultural, forestry and horticultural crops in the state and, in many cases, more widely across south-eastern Australia. The central plank of understanding insect-plant relation-

Fig. 1. ' "Cherry Borer" (*Maroga gigantella*).' From French (1891) Part I, Plate XIII, p. 112.

ships, the foundation of much modern pest management, was well understood by French. Despite the contemporary emphasis on pesticide uses, with any other deliberate control methods relatively unusual, French was clearly aware of the ecological relevance of biological control. He was an early advocate for protecting natural enemies of pest insects and referred repeatedly to the values of ladybirds as predators, for example, including the pioneering case of the Australian *Rodolia cardinalis* (Mulsant) exported to control Cottony Cushion Scale *Icerya purchasi* Maskell on Californian citrus in the nineteenth century (see back cover). He also referred to use of quassia chip extracts as a deterrent to the attack on bean crops by the lycaenid *Zizina labradus* (Godart)—quassia *Quassia amara* L. is recognised also as a contact insecticide. Of course, many aspects of modern pest management were unknown in French's day, but the primary needs leading to many of these (e.g. environmental safety and economics) were very familiar. His advocacy for insectivorous birds and native insect predators foreshadowed some aspects of modern conservation biological control.

Those interests flow from his lifelong interests in natural history, his familiarity with Australian flora consolidating from the age of 16, when he was apprenticed in the nursery trade. Subsequently, he was appointed to the staff of the Royal Botanic Garden and thence to the Phytological Museum of Melbourne (later to become the National Herbarium). French wrote extensively about ferns. He was also an avid insect collector and made three successive substantial collections of beetles. The last of these went to the National Museum, and his own collecting activities were augmented by his purchase of several notable beetle collections, with the whole collection containing a number of type specimens of species described by others—French himself did not describe new taxa. There is little doubt that French knew at first hand many of the insects he wrote about. Likewise, his enthusiasm for birds flowed largely from direct experience and observation. His writings in the Handbook were thereby authoritative and widely respected. They were also highly topical. The advice provided was by far the best available at the time, and guided growers and managers throughout the state. Not least, the Handbook was written in language easily understood by the primary readership, with a minimum of jargon and technical terminology, and clear explanations and descriptions that facilitated effective communication. French seems to have had an excellent rapport with farmers, and Hogan (1994: 281) noted that 'he frequently visited country centres'. Those contacts undoubtedly increased confidence in, and circulation of, the Handbook.

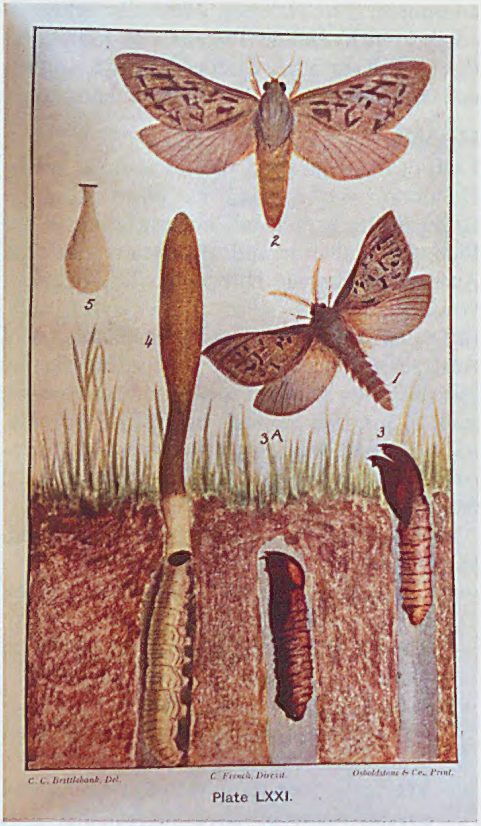

Fig. 2. ' "The Dark-Spotted Swift Moth" (*Porina fuscomaculata*, Walker.)' From French (1909) Part IV, Plate LXXI, p. 72.

The purpose of this paper is to modernise the value of these volumes by updating the published information on identification and nomenclature of all the arthropod taxa treated by French. The necessary changes are presented in an annotated checklist, constructed by the methods noted below. Publication of this

account in *The Victorian Naturalist* acknowledges French's role in 1880 as a co-founder of the Field Naturalists Club of Victoria, and his active membership for many years thereafter.

Methods

Each of the arthropod species featured in the Handbook was checked for information relating to the names and nomenclature in the following authentic and up-to-date resources: Australian Faunal Directory (https://biodiversity.org.au/afd); Atlas of Living Australia, (https://www.ala.org.au); CSIRO Handbook of Australian Insect Names (https://www.ento.csiro.au/index.html); taxon-specific catalogues, such as ScaleNet for scale insects (https://data.nal.usda.gov/dataset/scalenet-scale-insects-coccoidea-database), and relevant published papers.

The following modifications were undertaken, as needed:

- Corrections to spellings of genus, species, author and family names;
- Corrections and updates to common names;
- Provision of missing author names, family names, and also common names when available;
- Verification of status of each genus and species name by checking whether it is currently valid, synonymised with, or transferred to or combined with another genus; and
- Review of occurrences of certain pest species to ascertain their current status as exotic or endemic to Australia.

Results

The annotated checklist (Appendix 1) includes the following information:

Handbook and Updated/Current names arranged as follows: genus, species, author, common name/s when available, and family. The Handbook names are written exactly as they appear in French's volumes, including incorrect spelling. The species are presented in alphabetical order of the genus/species as they are presented in the Handbook, but grouped in their respective Order.

Handbook part number and page number for individual species are provided in Appendix I, in the Part: page column, e.g. Handbook Part I and page number 123, is presented as I:123. Note: Part I 1904 reprint version has minor pagination differences..

Comments include any obvious corrections needed, such as if a species is exotic, i.e. does not occur in Australia.

Acknowledgement

We thank John Wainer (Agriculture Victoria, Bundoora) for critically reviewing and checking the arthropod names in this paper.

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Appendix 1. Annotated checklist of Arthropod species discussed by Charles French

Class/ Order	Handbook name	Part: page	Updated/Current name	Comments
ARACHNIDA/ ACARINA	*Phytoptus pyri*: Pear phytoptus, Acarinae	I: 118	*Eriophyes pyri* (Pagenstecher), Pearleaf Blister Mite, Eriophyidae	
	Tetranychus telarius, Red Spider, Tetranychidae	I: 93	*Tetranychus urticae* Koch, Two-spotted Spider Mite, Tetranychidae	
HEXAPODA/ BLATTODEA	*Termes australis* Hagen, Victorian white ant, Neuroptera, Termitida	II: 137	*Nasutitermes exitiosus* (Hill), Termitidae	The species name T*ermes australis* Hagen does not exist, whereas *Termes australis* Walker does; the latter is now a suppressed name in favour of the junior synonym of *Nasutitermes exitiosus* (Hill), and is used here.
ORTHOPTERA	*Pachytelus australis* Br., Common Victorian Locust, Acrididae	III: 27	*Chortoicetes terminifera* (Walker), Australian Plague Locust, Acrididae	The species name *Pachytelus australis* Br. does not exist. However, based on the common name as well as accompanying plates and notes in the Handbook, the species has been interpreted as *Chortoicetes terminifera* (Walker) (e.g. see Hogan 1994), and is used here.
HEMIPTERA	*Aphis brassicae* Linn., Cabbage aphis, Aphididae	II: 165	*Brevicoryne brassicae* (Linnaeus), Cabbage aphid, Aphididae	
	Aspidiotus Coccineus Gennadius, Red scale of orange, Coccididae	II: 53	*Aonidiella aurantii* (Maskell), Red Scale, Diaspididae	
	Aspidiotus Nerii Bouche, Oleander scale, Coccididae	II: 47	*Aspidiotus nerii* Bouché, Ivy Scale, Oleander Scale, Diaspididae	
	Aspidiotus perniciosus Comstock, San Jose scale, Coccidae	III: 85	*Comstockaspis perniciosa* (Comstock), California Scale, San José Scale, Diaspididae	

Appendix 1. continued

Class/ Order	Handbook name	Part: page	Updated/Current name	Comments
HEMIPTERA	*Diaspis rosae* Sandberg, Rose and Raspberry scale, Coccidae	V: 53	*Aulacaspis rosae* (Bouché), Rose Scale, Diaspididae	The species name *Diaspis rosae* Sandberg does not exist. According to ScaleNet, *Diaspis rosae* (Bouché) is an old name combination for *Aulacaspis rosae* (commonly known 'rose scale or rose hard scale'). Also, *Diaspis* (*Aulacaspis*) *rosae* (Maxwell-Lefroy) is now *Aulacaspis tubercularis* Newstead, commonly known as 'cinnamon scale or mango scale'. Based on the common name, we consider it was the former that was intended by French.
	Dindymus versicolor, Harlequin fruit bug, Pyrrhocridae	I: 89	*Dindymus versicolor* (Herrich-Schäffer), Harlequin Bug, Pyrrhocoridae	
	Eriococcus coriaceus Maskell, Common gum scale, Coccidae	V: 89	*Acanthococcus coriaceus* (Maskell), Blue Gum Scale, Common Gum Scale, Gum Tree Scale, Rice Bubble Scale, Gumtree Scale, Eriococcidae	
	Frenchia casuarinae Maskell, She-oak scale, Coccidae	V: 57	*Frenchia casuarinae* Maskell, Asterolecaniidae	
	Icerya Purchasii Maskell, Cottony-Cushion scale, Coccididae	II: 37	*Icerya purchasi* Maskell, Cottony Cushion Scale, Monophlebidae	
	Lecanium berberidis Sch., Greater vine scale, Coccidae	V: 111	*Parthenolecanium persicae* (Fabricius), Grapevine Scale, Coccidae	
	Mictis Profana, Holy bug, Coraidae	IV: 69	*Mictis profana* (Fabricius), Crusader Bug, Coreidae	
	Mysus cerasi Fabr., Black peach aphis, Aphididae	II: 9	*Myzus cerasi* (Fabricius), Cherry Aphid, Aphididae	
	Mytilaspis Citricola Packard, Lemon leaf and peel scale, Coccididae	II: 85	*Lepidosaphes beckii* (Newman), Mussel Scale, Purple Scale, Diaspididae	
	Mytilaspis pomorum, Apple-bark scale, Coccidae	I: 77	*Lepidosaphes ulmi* (Linnaeus), Apple Mussel Scale, Diaspididae	
	Myzus sp., Green peach aphis, Aphididae	II: 3	*Myzus persicae* (Sulzer), Green Peach Aphid, Aphididae	

Appendix 1. continued

Class/ Order	Handbook name	Part: page	Updated/Current name	Comments
HEMIPTERA	*Myzus* sp., Plum aphis, Aphididae	III: 63	*Myzus persicae* (Sulzer), Green Peach Aphid, Aphididae	From the accompanying plate and the notes in the Handbook, this one appears to be the same as Green Peach Aphid, *Myzus persicae* (Sulzer).
	Phylloxera vastatrix Planchon, Phylloxera or grape louse of vine, Aphidae	II: 117	*Daktulosphaira vitifoliae* (Fitch), Grape Phylloxera, Phylloxeridae	
	Prosops pedisequus Buckton, Apple tree destroyer	IV: 55	*Prosops pedisequus* Buckton, Apple Tree Destroyer, Cixiidae	
	Pseudococcus albizziae Maskell, Dark purple wattle scale, Coccididae	IV: 51	*Melanococcus albizziae* (Maskell), Wattle Mealybug, Pseudococcidae	
	Psylla acaciae-Baileyana Froggatt, Cootamundra wattle psylla, Psyllidae	VI: 27	*Acizzia acaciaebaileyanae* (Froggatt), Psyllidae	
	Pulvinaria Maskelli Olliff., Saltbush scale, Coccidae	V: 101	*Pulvinaria maskelli* Olliff, Cottony Saltbush Scale, Coccidae	
	Rhyparochromus sp., Rutherglen fly-pest, Lygiaedae	I: 105	*Nysius vinitor* Bergroth, Rutherglen Bug, Lygaeidae	The name *Rhyparochromus* refers to an exotic genus of the family Rhyparochromidae and does not match with the plates or the notes provided in the Handbook.However, based on the common name as well as accompanying plates and notes in the Handbook, the species has been interpreted as *Nysius vinitor* Bergroth, and is used here.
	Schizoneura lanigera (Hausmann.),Woolly aphis or American blight, Aphidae	I: 35	*Eriosoma lanigerum* (Hausmann), Woolly Aphid, Aphididae	
	Siphonophora? sp., Orange aphis, Aphidae	II: 71	*Macrosiphum* (*Macrosiphum*) sp., Aphididae	According to <http://aphid.speciesfile.org/>, *Siphonophora* is a synonym of *Macrosiphum* (subgen. *Macrosiphum*).

Appendix 1. continued

Class/ Order	Handbook name	Part: page	Updated/Current name	Comments
HEMIIPTERA	*Siphonophora* sp. Wheat aphis Aphididae	III: 41	*Macrosiphum* (*Macrosiphum*) sp., Aphididae	According to <http://aphid.speciesfile.org/>, *Siphonophora* is a synonym of *Macrosiphum* (subgen. *Macrosiphum*).
THYSANOPTERA	*Thrips tabaci* Lindemann, Common thrips, Thripidae	V: 31	*Thrips tabaci* Lindeman, Onion Thrips, Thripidae	
COLEOPTERA	*AEsiotes notabilis* Pascoe, Silky oak weevil borer, Curculionidae	V: 107	*Aesiotes notabilis* Pascoe, Pine Bark Weevil, Hoop Pine Bark Weevil, Curculionidae	
	Araeocerus fasciculatus De Geer, Nutmeg beetle, Anthribidae	V: 75	*Araecerus fasciculatus* (DeGeer), Arecanut Weevil, Cocoa Weevil, Coffee Bean Weevil, Anthribidae	
	Aulacophora hilaris Boisd., Banded pumpkin beetle, Chrysomelidae	IV: 123	*Aulacophora hilaris* (Boisduval), Pumpkin Beetle, Chrysomelidae	
	Batocera Boisduvali Hope, Boisduval's fig-tree borer, Cerambycidae	V: 135	*Batocera boisduvali* (Hope), Great Figtree Borer, Cerambycidae	
	Batocera frenchi Van de Poll, Red-spotted fig-tree borer, Cerambycidae	VI: 63	*Batocera frenchi* Van de Poll, French's Longicorn, Cerambycidae	
	Belus bidentatus Donovan, Apricot beetle, Curculionidae	III: 45	*Rhinotia bidentata* (Donovan), Two-spotted Weevil, Belidae	
	Belus centralis, Apricot beetle, Curculionidae	III: 44	*Rhinotia centralis* (Pascoe), Belidae	
	Belus irroratus, Apricot beetle, Curculionidae	III: 44	*Rhinotia irrorata* (Jekel), Belidae	
	Belus suturalis, Apricot beetle, Curculionidae	III: 44	*Rhinotia suturalis* (MacLeay), Tailed Weevil, Belidae	
	Belus sp., Apricot beetle, Curculionidae	III: 44	*Rhinotia* sp., Belidae	

Appendix 1. continued

Class/ Order	Handbook name page	Part:	Updated/Current name	Comments
COLEOPTERA	*Bimia femoralis* Saunders, Apple-gum Bimia	IV: 111	*Bimia bicolor* White, Bimia Longicorn, Apple-gum Bimia, Apple-gum Borer, Cerambycidae	
	Bostrychopsis jesuita Fabr., Orange and fig tree borer, Bostrychidae	IV: 89	*Bostrychopsis jesuita* (Fabricius), Large Auger Beetle, Bostrichidae	
	Calandra granaria Linne., Grain weevil, Curculionidae	V: 75	*Sitophilus granarius* (Linnaeus), Granary Weevil, Curculionidae	
	Calandra oryzae Linne., Rice weevil, Curculionidae	V: 75	*Sitophilus oryzae* (Linnaeus), Rice Weevil, Curculionidae	
	Conotrachlelus nenuphar Herbst., Plum curculio Curculionidae	II: 21	*Conotrachelus nenuphar* (Herbst), Plum Curculio, Curculionidae	EXOTIC, restricted to North America (EPPO 2020); was included in the Handbook as a potential exotic threat.
	Cylas formicarius Fabr., Sweet-potato weevil, Curculionidae	V: 63	*Cylas formicarius* (Fabricius), Sweetpotato Weevil, Brentidae	
	Cyria imperialis Donov., Banksia borer, Buprestidae	III: 67	*Cyrioides imperialis* (Fabricius), Banksia Jewel Beetle, Buprestidae	
	Desiantha nociva Lea, Tomato weevil, Curculionidae	V: 41	*Listroderes difficilis* Germain, Vegetable Weevil, Brown Vegetable Weevil, Curculionidae	
	Diadoxus erythrurus White, Small diadoxus borer, Buprestidae	V: 49	*Diadoxus erythrurus* (White), Small Cypress Jewel Beetle, Buprestidae	
	Diadoxus scalaris Lap. et Gory, Large diadoxus borer, Buprestidae	V: 45	*Diadoxus regius* Peterson, Cypress Jewel Beetle, Buprestidae	
	Diphucephala colaspidoides Gyll., Cherry green-beetle, Scarabaeidae	II: 27	*Diphucephala colaspidoides* (Gyllenhal), Green Scarab Beetle, Scarabaeidae	
	Distichocera Macleayi Newman, Feathery-horned yellow-box borer, Cerambycidae	V: 97	*Distichocera macleayii* Newman, Macleay's Longicorn, Feather-horned Yellow-box Borer, Cerambycidae	
	Doticus pestilens, Apple beetle, Anthribidae	I: 83	*Araecerus palmaris* (Pascoe), Driedapple Beetle, Anthribidae.	

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Class/ Order	Handbook name	Part: page	Updated/Current name	Comments
COLEOPTERA	*Enneaphyllus aeneipennis* Thomson, Sassafras borer beetles, Cerambycidae	VI: 35	*Enneaphyllus aeneipennis* Waterhouse, Cerambycidae	
	Enneaphyllus rossi Blackburn, Sassafras borer beetles, Cerambycidae	VI: 35	*Enneaphyllus aeneipennis* Waterhouse, Cerambycidae	
	Hesthesis cingulata Kirby, Wasp-like timber-borers, Cerambycidae	VI: 23	*Hesthesis cingulata* (Kirby), Wasp-like Longicorn, Cerambycidae	
	Hesthesis piorator Pascoe, Wasp-like timber-borers, Cerambycidae	VI: 23	*Hesthesis plorator* Pascoe, Cerambycidae	
	Heteronyx picus Blanchard, Strawberry-plant beetle	VI: 67	*Heteronyx piceus* Blanchard, Peanut Scarab, Scarabaeidae	
	Leis conformis, Lady-bird	II: 6	*Harmonia conformis* (Boisduval), Common Spotted Ladybird, Coccinellidae	
	Leptops Hopei Schaenh., Apple-root borer, Curculionidae	I: 71; II: 93	*Leptopius robustus* (Olivier), Fruit-tree Root Weevil, Apple-root Borer, Curculionidae	
	Novius bellus (Blackburn)	II: 39	*Novius bellus* (Blackburn), Coccinellidae	
	Novius cardinalis, Australian Ladybird	II: 39	*Novius cardinalis* (Mulsant), Vedalia Ladybird, Coccinellidae	
	Orthorrhinus cylindrirostris, Fabr. Elephant beetle of the orange, Curculionidae	IV: 83	*Orthorhinus cylindrirostris* (Fabricius), Elephant Weevil, Curculionidae	
	Orthorrhinus Kluggi Schon, Vine curculio, Curculionidae	III: 59; O. klugii: IV: 87	*Orthorhinus klugii* Boheman, Vine Weevil, Vine Curculio, Curculionidae	
	Pachydissus sericus Newman, Greyish-horned beetle of the wattle, Cerambycidae	V: 131	*Pachydissus sericus* Newman, Cerambycidae	

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Class/ Order	Handbook name	Part: page	Updated/Current name	Comments
COLEOPTERA	*Paropsis orphana* Erichson, Fire-blight of wattle, Chrysomelidae	V: 37	*Peltoschema orphana* (Erichson), Fireblight Beetle, Chrysomelidae	
	Phoracantha recurva, Yellow-box borers, Cerambycidae	V: 71	*Phoracantha recurva* Newman, Yellow Longicorn, Cerambycidae	
	Phoracantha tricuspis, Yellow-box borers, Cerambycidae	V: 71	*Phoracantha tricuspis* Newman, Cerambycidae	
	Piesarthrius marginellus Hope, Acacia borer, Cerambycidae	III: 125	*Piesarthrius marginellus* Hope, Feather-horned Longicorn, Cerambycidae	
	Platypus cupulatus Chp., Curved wing-case timber borer, Scolytidae	V: 81	*Dinoplatypus cupulatus* (Chapuis), Curculionidae	
	Rhinaria perdix Pascoe, Strawberry beetle, Curculionidae	II: 175	*Pelororhinus perdix* (Pascoe), Strawberry Beetle, Strawberry Weevil, Curculionidae	
	Rhizopertha collaris, Apple-tree borer beetle, Bostrychidae	I: 61	*Mesoxylion collaris* (Erichson), Particoloured Auger Beetle, Bostrichidae	
	Rosenbergia megacephala Van de Poll, Rosenberg's fig tree borer, Cerambycidae	VI: 31	*Rosenbergia megalocephala* Poll, Cerambycidae.	
	Scolecobrotus westwoodi Hope, Mistletoe-borer, Cerambycidae	VI: 51	*Scolecobrotus westwoodii* Hope, Roughshouldered Longicorn, Cerambycidae	
	Stigmodera fortnumi Hope, Fortnum's wood-borer, Buprestidae	VI: 71	*Temognatha fortumii* (Hope), Buprestidae	
	Stigmodera heros Gehin., She-oak root borer, Buprestidae	V: 115	*Temognatha heros* Géhin, Buprestidae	
	Stigmodera vertebralis Donovan, Steel-Blue She-oak borer, Buprestidae	IV: 95	*Temognatha suturalis* (Donovan), Buprestidae	
	Strongylorhinus ochraceus Schaum.,Red gum-tree weevil	IV: 129	*Strongylorhinus ochraceus* Schönherr, Gregarious Gall Weevil, Curculionidae	
	Strongylurus cretifer Hope, Native-cherry borer, Cerambycidae	VI: 19	*Strongylurus cretifer* (Hope), Silverbirch Branchcutter, Cerambycidae	

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COLEOPTERA	*Tryphocharia mastersi* Pascoe, Masters' gum borer	IV: 99	*Phoracantha mastersi* (Pascoe), Eucalypt Ringbarker Longicorn, Cerambycidae	
	Uracanthus acuta, Apple and pear uracanthus beetle, Cerambycidae	VI: 39	*Uracanthus acutus* Blackburn, Apricot Longicorn, Cerambycidae	
	Uracanthus bivittata, Uracanthus timber borer, Cerambycidae	V: 67	*Uracanthus bivitta* Newman, Cerambycidae	
	Uracanthus simulans, Uracanthus timber borer, Cerambycidae	V: 67	*Uracanthus simulans* Pascoe, Cerambycidae	
	Uracanthus strigosus, Uracanthus timber borer, Cerambycidae	V: 67	*Uracanthus strigosus* Pascoe, Cerambycidae	
	Uracanthus triangularis Hope, Triangular-marked banksia beetle, Cerambycidae	III: 135	*Uracanthus triangularis* Hope, Triangular Marked Banksia Longicorn, Cerambycidae	
	Xenocnema spinipes Wall, var. *Australiae* Lea, Spined log beetle, Curculionidae	V: 127	*Xenocnema spinipes* Wollaston, Broad-nosed Kauri Weevil, Spined Log Beetle, Curculionidae	
DIPTERA	*Dacus (Tephritis) tryoni* Froggatt, Queensland fruit fly	IV: 37	*Bactrocera (Bactrocera) tryoni* (Froggatt), Queensland Fruit Fly, QFF, Qfly, Tephritidae	
	Gastrophilus equi Fabr., Horse bot fly	IV: 133	*Gasterophilus intestinalis* (De Geer), Horse Throat Bot Fly, Gasterophilidae	
	Halterophora capitata Wiedmann, Mediterranean fruit fly	IV: 29	*Ceratitis capitata* (Wiedemann), Mediterranean Fruit Fly, Medfly, Tephritidae	
	Lestophonus iceryae, Lestophonus fly	II: 38	*Cryptochetum iceryae* (Williston), Cryptochetidae	
	Lonchaea splendida, Metallic tomato fly, Trypetidae	V: 21	*Lamprolonchaea brouniana* (Bezzi), Metallic-green Tomato Fly, Lonchaeidae	
	Phytomyza affinis, Phytomyza leaf tunneller, Muscidae	III: 71	*Phytomyza affinis* Fallén, Agromyzidae	EXOTIC; restricted to Palaearctic Region and Canada (Pitkin *et al.* 2020).

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Class/ Order	Handbook name	Part: page	Updated/Current name	Comments
LEPIDOPTERA	*Agarista glycine* Lewin, Vine moth, Agaristidae	II: 101	*Phalaenoides glycinae* Lewin, Grapevine Moth, Noctuidae	
	Agrotis spina, Bugong moth, Noctuidae	III: 77	*Agrotis infusa* (Boisduval), Bogong Moth, Common Cutworm, Noctuidae	
	Agrotis sp., Cutworm moth, Noctuidae	III: 75	*Agrotis* sp., Noctuidae	
	Antherea eucalypti Scott., Gum emperor moth, Saturnidae	III: 113	*Opodiphthera eucalypti* (Scott), Emperor Gum Moth, Saturniidae	
	Artices glatignyi Butler, Light-striped tiger moth, Arctiidae	V: 27	*Spilosoma glatignyi* (Le Guillou), Woolybear Caterpillar, Black and White Tiger Moth, Erebidae	
	Cacaecia responsana, Light-brown apple moth, Tortricidae	I: 67	*Epiphyas ashworthana* (Newman), Tortricidae	The Light-brown Apple Moth is the common name currently applied to *Ephiphyas postvittana.* However, French did not consider this to be the species illustrated in the plates (I: Plate V: 68) and clearly explains that the moths do not in his opinion belong to this species but to *Cacaecia responsana,* now known as *Epiphyas ashworthana.*
	Carpocapsa pomonella Linn., Codlin moth, Tortricidae	I: 45	*Cydia pomonella* (Linnaeus), Codling Moth, Tortricidae	
	Chaerocampa celerio Linn., Silver-striped vine-moth, Sphingidae	II: 109	*Hippotion celerio* (Linnaeus), Grapevine Hawk Moth, Sphingidae	
	Charagia lignivora Lewin, Green hanging moth of apple, Hepialidae	IV: 77	*Aenetus ligniveren* (Lewin), Common Splendid Ghost Moth, Hepialidae	
	Clania ignobilis Walker, Lesser case moth, Psychidae	IV: 115	*Clania ignobilis* (Walker), Faggot Case Moth, Psychidae	
	Clania tenuis Rosenb., Clania case moth, Psychidae	VI: 87	*Clania lewinii* (Westwood), Psychidae	

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Class/ Order	Handbook name	Part: page	Updated/Current name	Comments
LEPIDOPTERA	*Comocrus behri* Angas, Behri mistletoe moth, Agaristidae	VI: 99	*Comocrus behri* (Angas), Mistletoe Moth, Noctuidae	
	Danima banksiae Lew., Banksia moth, Notodontidae	III: 121	*Psalidostetha banksiae* (Lewin), Banksia Moth, Notodontidae	
	Darala ocellata Walker, Common darala moth, Liparidae	V: 123	*Anthela ocellata* (Walker), Eyespot Anthelid, Anthelidae	
	Diacrisia canescens, Le G., Dark-striped tiger moth, Arctiidae	V: 27	*Spilosoma canescens* (Butler), Darkspotted Tiger Moth, Erebidae	
	Doratifera vulnerans Lewin, Mottled cup moth	IV: 143	*Doratifera vulnerans* (Lewin), Mottled Cup Moth, Limacodidae	
	Ephestia kuehniella, Mediterranean flour moth, Pyralidae	VI: 43	*Ephestia kuehniella* Zeller, Mediterranean Flour Moth, Flour Moth, Pantry Moth, Mill Moth, Pyralidae	
	Erechthias mystacinella, Curve-winged apple moth, Tineiniae	I: 57	*Erechthias mystacinella* (Walker), Tineidae	
	Eulechria melesella Newman, Lawn grubs, Oecophoridae	VI: 75	*Eulechria melesella* (Newman), Oecophoridae	
	Heliocausta mimica Meyrick, Cluster-leaved caterpillar, Oecophoridae	VI: 47	*Syringoseca mimica* (Meyrick), Oecophoridae	
	Heliothris armigera Hubn., Tomato moth, Noctuidae	III: 49	*Helicoverpa armigera* (Hübner), Corn Earworm, Cotton Bollworm, Tobacco Budworm, Noctuidae	
	Hyalarcta huebneri Westw., Huebner's case moth, Psychidae	IV: 59	*Hyalarcta huebneri* (Westwood), Leaf Case Moth, Leaf Bagworm, Psychidae	
	Hyalarcta nigrescens Ribbed case moth, Psychidae	VI: 95	*Hyalarcta nigrescens* (Doubleday), Ribbed Case Moth, Ribbed Bagworm, Psychidae	
	Hydrusa sp., Orange moth	II: 63	*Amata* sp., Erebidae	
	Limacodes longerans, Painted cup moth	IV: 143	*Doratifera oxleyi* (Newman), Painted Cup Moth, Limacodidae.	
	Lita solanella Boisd., Potato moth, Gelechidae	II: 147	*Phthorimaea operculella* (Zeller), Potato Moth, Gelechiidae	

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Class/ Order	Handbook name	Part: page	Updated/Current name	Comments
LEPIDOPTERA	*Mamestra Ewingi*: Cutworm moth, Noctuidae	III: 75	*Persectania ewingii* (Westwood), Southern Armyworm, Noctuidae	
	Maroga gigantella, Cherry borer, Gelichidae?	I: 113	*Maroga melanostigma* (Wallengren), Fruit-stem Borer, Pecan Stem Girdler, Oecophoridae	
	Metura elongata Saunders, Case moth of orange, Psychidae	II: 77	*Metura elongatus* (Saunders), Saunder's Case Moth, Psychidae	
	Mnesampela privata Gn., Blue gum moth, Selidosemidae	III: 55	*Mnesampela privata* (Guenée), Autumn Gum Moth, Geometridae	
	Nonagria sp., Spotted sugarcane moth, Noctuidae	VI: 55	*Nonagria* sp., Noctuidae	
	Oncoptera intricata Walker, Dark-green grass caterpillar	IV: 103	*Oncopera intricata* Walker, Corbie, Hepialidae	
	Papilio Anactus Macleay, Butterfly of the orange, Papilionidae	V: 17	*Papilio* (*Eleppone*) *anactus* Macleay, Small Citrus Butterfly, Dingy Swallowtail, Dainty Swallowtail, Papilionidae	
	Pielus hyalinatus HS Variety *imperialis* Oliff, Pielus moth, Hepialidae	VI: 83	*Abantiades hyalinatus* (Herrich-Schäffer), Hepialidae	
	Pieris teutonia Fabr., Caper butterfly, Pierineae s.fam.	III: 101	*Belenois java* ssp. *teutonia* (Fabricius), Caper White, Pieridae	
	Pinara nana, Pinara grub of apple	IV: 119	*Pararguda nana* (Walker), Lasiocampidae	
	Plodia interpunctella Hb., Lesser dried fruit moth, Pyralidae	V: 85	*Plodia interpunctella* (Hübner), Indian Meal Moth, Pyralidae	
	Plutella cruciferarum Zell., Cabbage moth, Tineina	II: 157	*Plutella xylostella* (Linnaeus), Cabbage Moth, Diamondback Moth, Plutellidae	
	Porina fusco-maculata Walk., Dark-spotted swift moth, Hepialidae	IV: 73	*Oxycanus antipoda* (Herrich-Schäffer), Oxycanus Grub, Hepialidae	

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Class/ Order	Handbook name	Part: page	Updated/Current name	Comments
LEPIDOPTERA	*Pyroderces semnostola* Meyr., Acacia moth, Elachistidae	VI: 91	*Cholotis semnostola* (Meyrick), Cosmopterigidae	
	Roeselia lugens Walker, Gum-tree moth, Arctiidae	V: 119	*Uraba lugens* Walker, Gumleaf Skeletoniser, Nolidae	
	Tinea granella Linn., Wheat moth, Tineidae	III: 129	*Nemapogon granella* (Linnaeus), Mottled Grain Moth, European Grain Moth, Tineidae	
	Teia anartoides Walk., Painted apple moth, Liparidae	III: 95	*Orgyia anartoides* (Walker), Painted Apple Moth, Erebidae	
	Zeuzera Eucalypti Boisd., Wattle goat moth, Zeuzeridae	III: 107	*Endoxyla encalypti* Herrich-Schäffer, Wattle Goat Moth, Cossidae	
	Zizera Labradus Godt., Common Bean butterfly, Lycaenidae	IV: 63	*Zizina labradus* ssp. *labradus* (Godart), Grass Blue Butterfly, Common Grass-blue, Lycaenidae	
HYMENOPTERA	*Perga dorsalis* Leach, Gum saw fly, Tenthridinidae	III: 117	*Perga dorsalis* Leach, Steelblue Sawfly, Pergidae	
	Phylacteophaga eucalypti Froggatt, Blister-leaf sawfly, Tenthridinidae	VI: 79	*Phylacteophaga eucalypti* Froggatt, Leafblister Sawfly, Pergidae	
	Selandria cerasi: Pear and cherry slug, Tenthredinidae	I: 99	*Caliroa cerasi* (Linnaeus), Pear and Cherry Slug, Tenthredinidae	

Dense regrowth following wildfire produced enhanced habitat for Mainland Dusky Antechinus *Antechinus mimetes mimetes* in an isolated vegetation block in the La Trobe Valley, Victoria

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Abstract
A population of Mainland Dusky Antechinus *Antechinus mimetes mimetes* increased significantly following wildfire in an isolated 44.7 ha native vegetation block in the Latrobe Valley, Victoria. Five years of post-fire dense regrowth on the edge of Damp Forest provided ideal habitat for this dasyurid marsupial. Although the largest part of the block was severely burnt, some unburnt areas survived, providing refugia for small mammals. This result provides evidence that mammal populations can survive wildfire provided that sufficient unburnt areas remain. It also shows that small, isolated blocks of native vegetation can play an important role in maintaining biodiversity, especially in highly fragmented landscapes. (*The Victorian Naturalist* **138**(5), 2021, 145–149)

Keywords: Mainland Dusky Antechinus, wildfire, refugia, dense regrowth, population increase

Introduction

Thirty-four offset areas, set aside for conservation purposes under an agreement with the Victorian Government, exist around the Yallourn coal mine in the Latrobe Valley, Victoria (Department of Natural Resources and Environment 2002). Monitoring of vertebrate fauna populations in these areas has been conducted since 2007 (Homan 2009; Homan 2019; Homan unpubl. 2011–2017). The landscape in this part of the Latrobe Valley is highly fragmented, with coal mines, power stations, railway lines, many roads, numerous towns, industrial areas, residential estates, timber plantations and farms.

Witt's Gully (38° 22' S, 146° 30' E), known as Block 34 under the Yallourn Mine Conservation Management Plan (YMCMP), covers 44.7 ha and is situated approximately 10 km west of Morwell. The block is isolated from other native vegetation and contains two Ecological Vegetation Communities, with Damp Forest in the lower gully section and Lowland Forest on the slopes (Homan 2009).

In February 2014, a severe bushfire, known as the Morwell Fire, burnt approximately 90% of Witt's Gully. The impact of this fire varied across the two vegetation communities, with the higher slopes being burnt more severely than the lower, damper areas (Fig. 1). At the base of the Lowland Forest on the north side of the gully, amongst a tangle of fallen branches, dense vegetation up to 2 m above ground level had developed 5 years post-fire (Fig. 2).

Intensive surveys of vertebrate fauna at Witt's Gully were conducted on two occasions before the Morwell Fire; in April 2008 (Homan 2009) and in February 2012 (Homan unpubl. 2012). The post-fire survey was conducted from 8–11 April 2019.

The surveys were commissioned by TRU Energy Pty Ltd and EnergyAustralia Pty Ltd and were conducted by Peter Homan Fauna Consultancy, with overall project management by Indigenous Design Environmental Management Pty Ltd, Morwell.

Methods

Elliott trapping (Type A, folding aluminium traps by Elliott Scientific Equipment, Upwey, Victoria) was the principal survey technique used to determine the presence of small, terrestrial mammals during each survey. Remote surveillance cameras were used during the 2012 pre-fire survey (Scoutguard model SG-550V) and during the post-fire survey in 2019 (Scoutguard models KG-680V and SG-990V and Faunatech Snaps). Live-trapping and camera-trapping were conducted over four days

Fig. 1. Sparse regrowth on slope in Lowland Forest, five years post-fire.

Fig. 2. Dense regrowth up to 2 m tall on edge of Damp Forest.

and three nights on each occasion. Elliott traps were set 10 m apart in lines of 10 at various sites throughout the gully and across the adjoining slopes. Baits for live-trapping and camera-trapping consisted of a mixture of quick oats, smooth peanut butter and golden syrup. In 2012, cameras were set to record a 20-second video every five seconds and, during the 2019 study, cameras were set to take three still images every five seconds. Cameras were set in groups of three, approximately 20 m apart at various sites throughout the study area.

Overall, 636 trap-nights were completed, with 150 Elliott trap-nights in April 2008; 210 Elliott

Table 1. List of small mammals and number recorded pre- and post-wildfire.

Common Name	Scientific Name	2008	2012	2019
Agile Antechinus	*Antechinus agilis*	56	31	38
Mainland Dusky Antechinus	*Antechinus mimetes mimetes*		1	10
Bush Rat	*Rattus fuscipes*	20	43	30
Swamp Rat	*Rattus lutreolus*			2
House Mouse	*Mus musculus*	1		2

trap-nights and 18 camera-nights in February 2012; and 210 Elliott trap-nights and 48 camera-nights in April 2019.

Results

Five species of small mammals were recorded (Table 1). Mainland Dusky Antechinus *Antechinus mimetes mimetes* (Fig. 3) was recorded once pre-fire and in greater numbers five years post-fire. Significant numbers of Agile Antechinus *A. agilis* and Bush Rat *Rattus fuscipes* were recorded pre- and post-fire. Swamp Rat *R. lutreolus* was recorded post-fire and House Mouse *Mus musculus* was recorded once in 2008 and twice in 2019.

Discussion

The Mainland Dusky Antechinus is a small, insectivorous dasyurid marsupial found over a wide area of south-eastern Australia, from northern New South Wales to south-western Victoria (Baker *et al.* 2015). Two subspecies are recognised in Victoria (Baker *et al.* 2015): *A. mimetes insulanus* is confined to the Grampians, where it has been recorded in both wet and dry vegetation communities (Menkhorst and Homan unpubl. 2003; Homan 2008; Stevens 2008; Homan and Schultz 2012). *Antechinus mimetes mimetes* is found in other parts of Victoria where it usually inhabits dense, wet vegetation up to 1 m above ground level (Baker *et al.* 2015).

Fig. 3. Mainland Dusky Antechinus. Photo Peter Bird.

Four species of the genus *Antechinus* inhabit various parts of Victoria (Menkhorst and Knight 2011). The Agile Antechinus, which is common in many parts of southern and eastern Victoria, is mostly nocturnal (Menkhorst and Knight 2011). The Swamp Antechinus *A. minimus* is partly diurnal, whilst the Yellow-footed Antechinus *A. flavipes* is the most diurnal of the four species (Menkhorst 1995). The Mainland Dusky Antechinus is also partly diurnal and has been captured on a number of occasions during daylight hours in the Latrobe Valley (Homan 2011) and in the Grampians National Park (Homan and Schultz 2012).

Several studies have confirmed the survival of dasyurid populations following wildfire. Agile Antechinus populations were found to have survived the Black Saturday fires in Victoria (Banks *et al.* 2011) and following a severe wildfire in the Nadgee Nature Reserve in New South Wales (Lunney *et al.* 2008). Yellow-footed Antechinus populations survived major wildfire in western Victoria (Homan 2012) and in the Warrumbungle National Park in north-central New South Wales (Matthews *et al.* 2017). A population of Swamp Antechinus recovered following severe wildfire in the Otway Ranges in Victoria (Wilson and Moloney 1985). Several other studies in large areas of contiguous native vegetation have confirmed the survival of small populations of Mainland Dusky Antechinus (Lunney *et al.* 2008; Stevens 2008; Davies and Drew 2014; Swan *et al.* 2015; Burns *et al.* 2016). A common feature of all post-fire studies is the presence of unburnt refugia in damp gullies. There is, however, a lack of studies showing survival of Mainland Dusky Antechinus

populations in small, isolated areas of native vegetation, especially in highly fragmented landscapes, that also provide pre- and post-fire data.

During the 2012 survey, 30 Elliott traps, set for two nights in the damp gully, failed to capture Mainland Dusky Antechinus. Whilst checking traps at dawn, a relatively small area of approximately 1 ha, with especially dense vegetation to 1 m above ground level, was identified as potential habitat for Mainland Dusky Antechinus. This site was in Lowland Forest at the bottom of the slope immediately adjacent to the damp gully. Ten traps were moved to this area and were set for daylight sampling early on the morning of 22 February 2012. When these traps were checked at noon, one adult male Mainland Dusky Antechinus had been captured.

During the 2019 survey, 30 Elliott traps and three surveillance cameras were set amongst dense vegetation at the above site and in the adjacent gully. This area of dense vegetation had increased to approximately 5–6 ha five years post-fire. Over three nights of trapping, 10 Mainland Dusky Antechinus (five males and five females) were captured. Elliott traps were not set for daylight sampling during the 2019 survey. Surveillance cameras, however, failed to capture any images of Mainland Dusky Antechinus. Captured animals were not weighed or marked, so it is possible that some recaptures may have occurred. Nevertheless, the 2019 result represented a significant increase in the capture rate for this species compared to the two previous studies. It seems that the habitat for Mainland Dusky Antechinus had improved markedly at Witt's Gully five years post-fire.

The site where a Mainland Dusky Antechinus was captured in 2012 was severely burnt by the Morwell Fire in 2014. When wildfire burns areas of vegetation, small mammals may survive in unburnt refugia such as damp gullies and recolonise areas or survive as residual populations (Lindenmayer *et al.* 2008; Banks *et al.* 2011; Burns *et al.* 2016). The results from the 2019 post-fire survey indicate that a small population of Mainland Dusky Antechinus survived in parts of the unburnt gully and recolonised surrounding areas because vegetation regrowth provided suitable habitat.

Whilst Witt's Gully is a relatively small conservation area, long-term surveys in this block provide further evidence that small areas of indigenous vegetation can be important for local biodiversity conservation (Wintle *et al.* 2018). These results also show that researchers planning and conducting vertebrate field studies should not dismiss small, isolated vegetation areas as being unworthy of appropriate survey effort.

Acknowledgements

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A new *Hakea* species (Proteaceae: Grevilleoideae) from the Upper Genoa River, East Gippsland, Victoria

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Abstract
A new species of *Hakea* Schrad. & J.C.Wendl. is described. *Hakea yambulla* Molyneux & Forrester sp. nov. is a rare shrub with a restricted known distribution in the Coopracambra National Park, East Gippsland, Victoria. Its relationship with *Hakea eriantha* R.Br. is discussed and critical differences noted. The authors have made only one field collection of this new species, as fruit in 1979. None of the five types described by Gandoger (1919) as novel species and synonymised under *H. eriantha* by Barker *et al.* (1999) represent this new species. No earlier herbarium collections could be located for *H. yambulla*, which is described from a type grown on the authors' property. Distribution, affinities and conservation status of the new species are discussed. (*The Victorian Naturalist* **138**(5), 2021, 149–155)

Keywords: *Hakea yambulla, Hakea eriantha*, new species, conservation status, taxonomy

Introduction
In May 1979, while studying *Grevillea* populations in the Upper Genoa River district of East Gippsland, the authors observed a *Hakea* growing on and around a rocky knoll on the lower Yambulla Peak Track, overlooking the east side of the Genoa River. While recognising this *Hakea* had affinities with the widespread and locally occurring *H. eriantha*, we noted that it differed by its smaller stature, smooth bark on the lower trunk, much broader leaves and much smaller fruit. A small stand of 20–50 (–100) mature plants of this unknown *Hakea* occurred within an area of about 0.1 ha. Flowering had finished and we intended to return during a subsequent flowering season to collect herbarium specimens; however, mature fruit were present and collected. Time constraints limited the opportunity to explore for further plants or populations. Given the remote location and the succession of fire events known or

suspected to have subsequently compromised the opportunity to collect mature specimens, no further specimens have been collected in the wild in the past 32 years.

Differences between the two species

Seed extracted from fruit collected from the Yambulla Peak Track population and from plants of *H. eriantha* on the lower Black Jack Gully Track above the west bank of the Genoa River were germinated in low phosphorus potting mix. When seedlings were approximately 10–20 cm tall, eight of each species were planted on a 0.2 ha area of the authors' property in Dixons Creek, Victoria, in 1981. Observations of differences between the two species were recorded annually through all stages of seasonal development until plants were severely damaged in the Victorian Black Saturday wildfires of February 2009. Major differences between the two species are described below and detailed in Table 1.

Vegetative differences

Seedlings of the two species consistently differed from each other (Figs 1 and 2), those of *H. yambulla* had broad leaves and green stems while *H. eriantha* had narrow leaves and red stems. *Hakea yambulla* developed into a medium sized, dense shrub, 1.5–2.5 m high and 1–2 m wide with smooth to lightly textured bark throughout. *Hakea eriantha* became a large spreading shrub to small tree, 3–8 m high and 3–6 m wide with tessellated bark that fissured with age, flaking to vertically interwoven on upper branches. Juvenile leaves of *H. yambulla* were ovate, c. 8.5 cm long and 4 cm wide, while adult leaves were broadly lanceolate to obovate, (5.5–) 10 (–12) cm long and (1.8–) 2.8 (–3.4) cm wide. Juvenile leaves of *H. eriantha* were broadly linear to lanceolate, c. 7.8 cm long and 0.9 cm wide. Adult leaves of the species are semi-pendulous, (7.5–) 14 (–18.5) cm long and (1–) 10–20 (–30) mm wide. Further plantings of each species from 2012 to 2019 also showed these differences (Figs 3 and 4). Intermediate forms never occurred.

Differences in flowering and fruiting

During the 28-year period of observation from 1981 to 2009, plants of *H. yambulla* and *H. eriantha* grown on the authors' property

Fig. 1. Seedlings (A) *Hakea yambulla* illustrating broader leaves and green stems; (B) *H. eriantha* with narrow leaves and red stems.

Fig. 2. Young plants of *Hakea eriantha* (left) illustrating the narrow green leaves and *H. yambulla* (right) with broader leaves with secondary colour patterning.

Fig. 3. *Hakea yambulla* (left) and *H. eriantha* (right), showing differences in habit, leaf size and posture in third generation plants.

Fig. 4. Close up showing the random seasonal tinting of the leaves of *Hakea yambulla* (left) and sericeous new tip growth of *H. eriantha* (right) in third generation plants.

displayed a significant and consistent difference in flowering times (Figs 5 and 6). *Hakea eriantha* flowered from mid-August to mid-September and *H. yambulla* from late September to late October (Fig. 6). While *H. eriantha* commenced anthesis in early to mid-August and spent flowers developed incipient fruits in early September, the flowers of *H. yambulla* were still in early bud stage (Fig. 5) and were not receptive to pollination until mid to late September. Incipient fruits were not evident on *H. yambulla* until early to mid-October by which time well-formed fruits of *H. eriantha* were evident. A 3-year-old fruit of *H. eriantha* is shown in Fig. 5. This flowering and fruiting pattern has been consistent for consecutive years of further plantings, from 2012–2019, with only minor seasonal variations.

Size of fruits (Fig. 5) and seeds clearly distinguished the two species. Fruits of *H. yambulla* were 23–26 mm long, 10–13 mm wide and had a 2–3 mm long apiculum. Seeds were narrowly obovate and 16.5–17 mm long. Fruits of *H. eriantha* were longer (25–30 mm in length) and wider (26–30 mm in width). The apiculum also was longer than in *H. yambulla*, with a length of 3–6 mm. Seeds were obliquely narrowly obovate and were 19.5–20.5 mm long, markedly longer than those of *H. yambulla*.

Response to fire

Hakea yambulla showed post-fire regeneration through seed and root suckering (Figs 7 and 8). Lignotubers were not observed. A rootstock

Fig. 5. *Hakea eriantha* (top) with narrow leaves, incipient fruit and 3-year-old fruit; and *H. yambulla* (lower) with broader leaves, developing buds and maturing fruit.

Fig. 6. *Hakea yambulla* flowering mid-October 2015.

from a fire-damaged plant is shown in Fig. 7 and subsequent suckering in Fig. 8. Plants that regenerated from suckering flowered and set fruit in late spring of 2012. *Hakea eriantha* regenerated by seed and, although it has rarely been known to sucker or develop a lignotuber, coppice shoots, which have since perished, were initiated by the 2009 fire from a large lignotuber in a 28-year-old specimen grown on the authors' property (Fig. 9). Vigorous suckers, which have persisted, were also produced

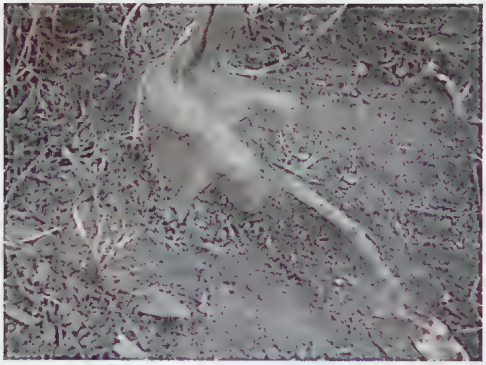

Fig. 7. Rootstock of a fire-damaged plant of *Hakea yambulla* following February 2009 fire.

Fig. 8. Regrowth from rootstock of *Hakea yambulla* in 2019.

from a small-diameter exposed surface root 5 m from the parent stem (Fig. 10).

Discussion

In view of the character state differences documented above and in Table 1, and the inferred flowering time barrier to cross breeding between the two entities, we consider that *H. yambulla* is worthy of recognition at the rank of species. None of the five types described by Gandoger (1919) as novel species and synonymised under *H. eriantha* by Barker *et al.* (1999) represent this new species and no other populations represented by collections at the National Herbarium of Victoria (MEL) represent this new species. With the description of a second species allied to *H. eriantha*, the informal *Eriantha* Group, as circumscribed by Barker *et al.* (1999), ceases to be monotypic. The *Eriantha* Group has been traditionally

Fig. 9. Single small coppice shoot, which has since perished, on lignotuber at base of extended large root of a 28-year-old specimen of *Hakea eriantha* growing in close proximity to the regenerated *H. yambulla* in Fig. 8.

Fig. 10. Vigorous root suckers, which have persisted, on small diameter root exposed for 5 m from base of *Hakea eriantha*.

included in the monotypic series *Pubiflorae* in the section *Hakea*. Key characters which distinguish the new species from *H. eriantha* are the dense upright shrubby habit, the broader, obovate adult leaves, the later, non-overlapping flowering time and the consistently smaller, ellipsoid fruit.

Taxonomy

Hakea yambulla Molyneux & Forrester sp. nov.

Type: Grown at the property of the authors: Dixons Creek, 37° 35' 55" S, 145° 26' 17" E, W.M. Molyneux, 19.x.2008 ex fruit collected from the following location: Victoria. Yambulla Peak Track above the east side of the Upper Genoa River, c. 500 m from the NSW border, 37° 16' 10" S, 149° 22' 10" E, elevation c. 410 m ASL, W.M. Molyneux & S.G. Forrester, v.1979; Holotype: MEL 2437685 and MEL 2437686.

A small to medium upright *shrub* 1.5–2.5 m high, 1–2 m wide. *Stem* 8 cm diameter at ground level at 10 years after germination with smooth or lightly textured grey bark. *Branchlets* lightly ridged longitudinally, often also arising from the lower main stem in one or more secondary stems. *Leaves* broadly lanceolate to obovate, (5.5–) 10 (–12) cm long, (1.8–) 2.8 (–3.4) cm wide, margins undulate thickened, widest at or above mid-point, shortly mucronate, primary and secondary venation obvious on upper and lower surfaces. Upper surface YELLOW-GREEN 148A (Royal Horticultural Society Colour Chart 1986), lower leaf surface GREEN-GROUP 138A, glabrous. New growth sericeous, quickly glabrescent, juvenile leaves strongly marked with patches of GREYED-PURPLE 185C. Maturing leaves often coloured seasonally with GREYED-PURPLE 185C markings on upper leaf surface and venation; less so on leaf undersurface. *Inflorescences* axillary, bracteose with (1–) 2–3 (–6) flowers. *Involucre* 3.25 mm long, 2.25 mm wide, fawn, sericeous on upper surface, early deciduous. *Pedicels* (1.5–) 3–4 (–4.5) mm long, densely sericeous. *Perianth* 5–5.5 mm long, 1.2 mm wide, densely sericeous. *Torus* oblique at c. 20–25°. *Nectary* crescentic, margins irregular, c. 0.2 mm deep. *Stipe* of ovary c. 0.5 mm long. *Ovary* c. 1 mm long. *Pistil* 8–9 mm long, green maturing to honey tone YELLOW-ORANGE 22A, glabrous. *Pollen-presenter* lateral or marginally oblique to style end, face shallowly concave, margins thickened, c. 1.5 mm long and wide, gland 0.15 mm high. *Fruit* ellipsoid, smooth, irregularly pusticulate, outer surface light green with irregular markings of GREYED-ORANGE 177B, 23–26 mm long, 10–13 mm wide, apiculum 2–3 mm long, stalk of fruit 3–4.5 mm long, 1–1.7 mm wide, width of wood zone of fruit at juncture of seed and wing 3.5–4 mm, commencing dehiscing at c 5 months, seed seldom retained for more than a year. *Seed* narrowly obovate, wing apical only, 7–8.5 mm wide.

Specimens examined: **VICTORIA** (Grown at the authors' property ex type locality): W.M. Molyneux & S.G. Forrester, 26.x.1987 (AD 98835005 flowering); W.M. Molyneux & S.G. Forrester, 15.iii.1988 (AD 98947237 fruiting).

Flowering period: Late September to late October.

Distribution and habitat: *Hakea yambulla* is known from only one locality on the Yambulla Peak Track above the east side of the Upper Genoa River in far East Gippsland, Victoria, c. 500 m from the NSW border, at an elevation of approximately 410 m ASL. Geology of the site is fossilised Devonian sandstone. Vegetation in the area is Shrubby Dry Forest EVC 21 dominated by Silvertop Ash *Eucalyptus sieberi* and White Stringybark *Eucalyptus globoidea* with Black Sheoak *Allocasuarina littoralis* locally abundant in the understorey.

Conservation Status: The new species is currently known by only the one collection of fruit in 1979 from which seed were extracted and plants propagated over several generations at the authors' property at Dixons Creek, Victoria.

In the absence of intensive searches at the type location, it is unclear whether the type population survives and, if so, whether it is stable or in decline. Observations of the type population in 1979 suggest the stand occupied a minimum area of no more than 35 m length and 30 m width on and around a sandstone outcrop to the south of the Yambulla Peak Track. The stand therefore occupied no more than 0.1 ha.

Population size is estimated to have been in the range 20–50 (–100) mature individuals in 1979. The only plausible threats to the species are likely to be extreme and protracted drought, which may be significant in the only known elevated topographic setting, repeat fire events and, potentially, targeted browsing by Sambar, particularly during early stages of post-fire regeneration or recruitment. The observed root suckering capacity of the species suggests it is unlikely to be threatened by low frequency fires of any intensity. Seed predation by cockatoos is likely to threaten the species only in combination with other threats such as drought and fire, from which full recovery may rely heavily on successful seed recruitment. Using the criteria of the IUCN (2001), the species is assessed as critically endangered, with a conservation code of CR B1ab(iii)+2ab(iii); D, on account of the current and projected impact of climatic drying and warming, increasing fire frequency and herbivory by Sambar and its very small inferred population size.

Etymology: The specific epithet is a noun in apposition which is the name for the district extending east and north-east from the slopes of Yambulla Peak and includes Nungatta and Mt Poole. The name was probably given to the surveyor Francis MacCabe in 1846 by local Aboriginal people. Yambulla is from the Thaua dialect (John Blay pers. comm. 2009).

Recommended English name: Yambulla Hakea.

Table 1. Comparison of character states for *Hakea yambulla* and *Hakea eriantha*. Measurements and observations were undertaken from herbarium specimens (*H. eriantha*) and material grown at the authors' property (*H. yambulla* and *H. eriantha*). Plants were grown from seed of *H. yambulla* sourced from the Yambulla Peak Track on the Upper Genoa River in Victoria, close to the Victorian–New South Wales border, and from seed of *H. eriantha* sourced from the lower Black Jack Gully Track. Colour codings are derived from the 1986 edition of the Royal Horticultural Society Colour Chart.

Character	*Hakea yambulla*	*Hakea eriantha*
Seedlings	Leaves broad, stems green	Leaves narrow, stems red
Habit	Medium sized upright dense shrub 1.5–2.5 m high, 1–2 m wide before 2009 fires, then following post-fire regeneration in 2018 and 2019, 1.8 m high, 85 cm wide	Large spreading shrub to small tree 3–8 m high, 3–6 m wide, ends of stems declined, often weeping
Bark and stem	Bark smooth to lightly textured throughout. Stem 8 cm diameter at ground level in third generation seed-grown plants at 10 years as well as post-fire root sucker at 7 years	Bark tessellated, fissured with age, flaking to vertically interwoven on upper branches. Stem c. 65 cm circumference at ground level at 28 years
Juvenile leaves	Ovate, GREEN-GROUP 139B, subglaucous above, often with strong secondary markings of GREYED- PURPLE 185C, light green beneath GREEN-GROUP 138C, c. 8.5 cm long, 4 cm wide	Broad linear to lanceolate, dark green above, mid green beneath, c. 7.8 cm long, 0.9 cm wide, new tips sericeous, soon glabrous, no secondary colouring evident
Adult leaves	Broadly lanceolate to obovate, texture thinnish but with thickened margins, irregularly undulate, primary and secondary venation obvious on both surfaces, widest at or above mid-point, seasonal marking of GREYED-PURPLE 185C noted on both surfaces (5.5–) 10 (–12) cm long, (1.8–) 2.8 (–3.4) cm wide	Linear lanceolate to narrowly elliptical, texture thickish, margins not undulate, venation obscure on both surfaces, widest at or below mid-point, semi-pendulous, (7.5–) 14 (–18.5) cm long, (1–) 10–20 (–30) mm wide

Table 1. (cont.)

Character	*Hakea yambulla*	*Hakea eriantha*
Flower	Inflorescence axillary with (1–) 2–3 (–6) flowers; involucre 3.25 mm long, 2.25 mm wide; pedicels (1.5–) 3–4 (–4.5) mm long, densely sericeous with white hairs. Perianth 5–5.5 mm long, 1.2 mm wide, densely sericeous, white. Pistil 8–9 mm long, green maturing to honey tone, YELLOW-ORANGE 22A below pollen presenter, glabrous. Pollen presenter lateral or marginally oblique below style apex, face shallowly concave, margins thickened, 1.5 mm long and 1.5 mm wide; gland 0.15 mm high	Inflorescence axillary with 6–10 flowers; involucre c 2.5 –3.5 mm long; pedicels 2.5–6 mm long, densely pubescent with white hairs extending on to perianth. Perianth 3.5–6.5 mm long, white but not sericeous. Pistil 7–8.5 mm long, green with light honey tone, YELLOW-ORANGE 22B below pollen presenter. Pollen presenter lateral below style apex, 1.2–1.5 mm long; gland 0.2 mm high
Flowering Period	Late September to late October	Mid-August to mid-September
Fruit	Ellipsoid, smooth, irregularly pusticulate, outer surface light green with irregular patterns of GREYED-ORANGE 177 B along the sutures and fruit body; ageing to GREYED-BROWN 199D, 23–26 mm long, 10–13 mm wide, apiculum 2–3 mm long. Commences dehiscing within six months of maturing and seldom retained beyond a year; seed narrowly obovate, 16.5–17 mm long; wing apical only; width of wood zone at point of seed and wing juncture 3.5–4 mm. Energetically predated by Yellow-tailed Black Cockatoos (*Calyptorhynchus funereus*)	Obovate to broadly obovate, sub-sigmoid, smooth becoming pusticulate, outer face GREYED-BROWN 199B ageing to GREY-GROUP 201A, decorticating regularly with age, 25–30 mm long, 26–30 mm wide, apiculum 3–6 mm long. Fruit and seed can be retained for three or more years, often becoming embedded in upper stems and branches; seed obliquely narrowly obovate, 19.5–20.5 mm long; wing apical only; width of wood zone at point of seed and wing juncture 8.5 mm. Occasionally eaten by Yellow-tailed Black Cockatoos
Recruitment	Recruitment by seed and root suckers. Not observed to be lignotuberous	Recruitment by seed. Rarely observed to be lignotuberous although coppice shoots and root suckers were initiated by 2009 fire from large lignotuber and exposed root respectively in cultivated specimens at Dixons Creek

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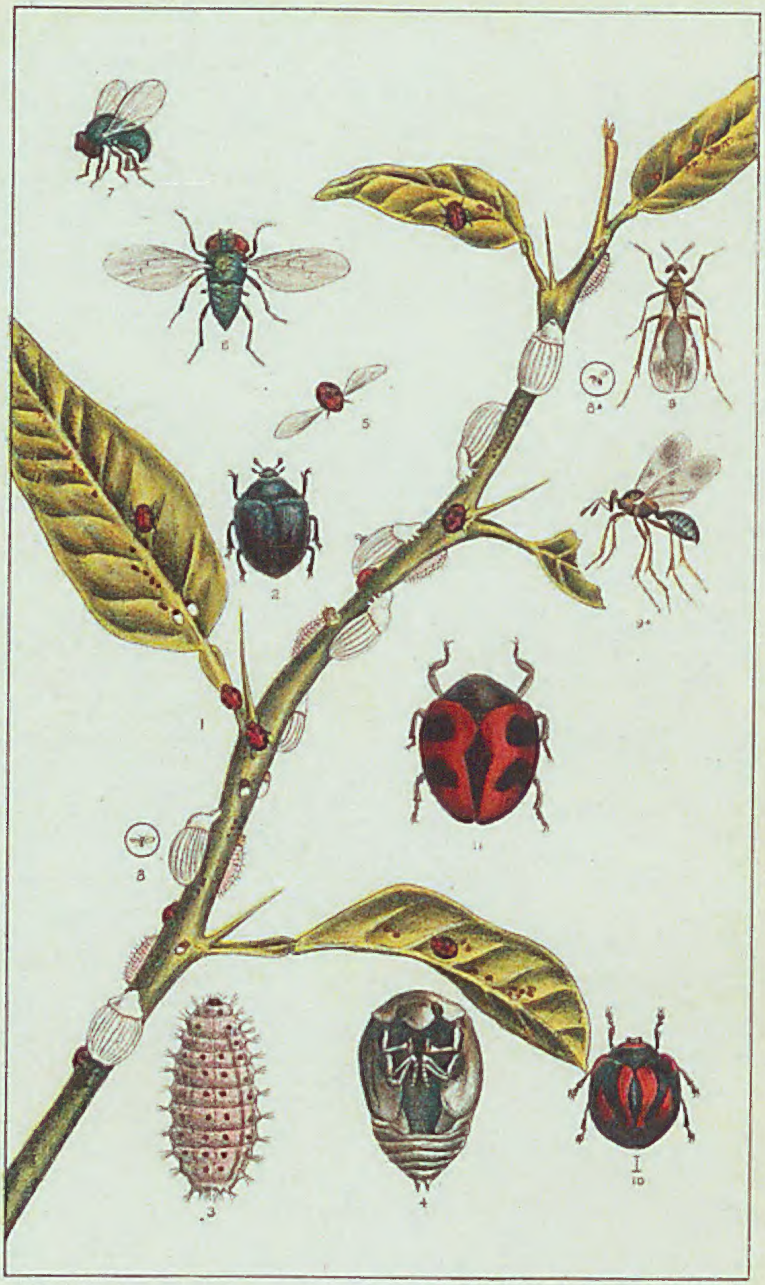

Plate XIX.